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The Finsen Light

BY

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Professor of Electro-Therapeutics, College of Physicians and Surgeons of San Francisco

(Read before the San Francisco County Medical Society, June 13, 1905)

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THE FINSEN LIGHT.

By F. C. KECK, M. D.,
Professor of Electro-Therapeutics, College of Physicians and Surgeons of San Francisco.

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Prof. Niels R. Finsen gave the first public notice of his light treatment in 1893. In 1896 he gave out his first treatise in Danish; up to that time he had cured 11 patients of lupus vulgaris. In 1899 he translated his treatise into German, adding an account of the progress and experiments made in the course of the three years intervening, together with a history of 300 cases of lupus vulgaris and about 100 other diseases of the skin successfully cured. In 1896 he opened the Finsen Light Institute in Copenhagen, being assisted financially by Messrs. Hageman, Wilhelm Jorgensen, the King of Denmark, the Carlsberger Fund and the Community Hospital.

In his work he was assisted by Drs. Reyn, Forchamer, Larsen, Elschon-Holm, Schmidt, and Prof. Halslund, Dermatologist of the Community Hopital. Most of these physicians are at the present time connected with the Institute and are continuing the work under the direction of Drs. Reyn and Forchamer. In 1903 Finsen had a history of 800 cases of lupus vulgaris cured.

The discovery that light is deadly to bacteria is not to be credited to Finsen alone. We have Dawnes and Blunts. Researches on the effect of light upon bacteria and other organisms, in the *Proceedings of the Royal Society of London*, as early as 1877 (Vol. XXVI, p. 48). And Geisler gave a dissertation in the *Centralblatt fur Bakteriologie*, on the ''Effect of Light on Bacteria, in 1892 (Vol. XI., p. 161). (*Zur Frage uber die Wirkung des Lichtes auf Bakterien.*

In 1894 Dieudonne proved that direct sunlight in the summer months would kill spores in the short time of one to two hours, diffused daylight in about five hours, electric arc light of 900 candle power in eight hours, and incandescent light in 11 hours. It was generally believed that light would cause oxidation of the bacteria. Dieudonne

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claimed that there was a formation of $H_2 O_2$. This theory was also advanced by Richardson in 1893.

The Interior of the Finsen Light Institute of Copenhagen.

It was for Finsen to find: 1. Which part of the spectrum is the most useful to destroy bacteria. 2. How can the deadly rays be separated. 3. Will light kill all bacteria. 4. Will all bacteria require the same length of time for their destruction.

Some writers attributed the deadly work to the red rays, others to the blue. Finsen thought it was the work of the violet or ultra-violet. This fact was borne out by his experiments and the successful work which he did during the succeeding 12 years. The theory on which Finsen worked was, that the purity of sea and river water was due to the influence of sunlight, and that strong sunlight was a great disinfectant. This was also investigated by Esmarch in 1894. In his research he found that sunlight would only disinfect whatever was in direct contact with the sun rays and that it had no penetrating power.

Finsen endeavored to construct an apparatus which would collect the sun rays, so that they would be powerful enough to kill bacteria in a reasonably short time and also penetrate to the deeper structures without injuring the tissues. To accomplish this it was necessary to have as much light as possible, but the more of the sun rays collected, the greater was the heat.

In order to have a strong penetrating light without heat, it was necessary to separate the heat rays, which are the red, ultra-red and orange. The warmest rays, the ultra-red, Finsen found could be absorbed by passing the light through a layer of alum water, but that left the heat too great, when the light was brought to a focus. It was necessary to remove the red, orange and yellow rays, allowing only the violet and ultra-violet to pass. This Finsen was partly successful in doing by passing the light through water colored blue, or through blue glass. The water was preferable on account of the difficulty in obtaining blue lenses evenly colored. Water also could be regulated according to the strength of the sunlight.

At first Finsen used a solution of ammoniated sulphate of copper. This was very good in removing the heat rays, but not practical, because the solution soon changed color from coming in contact with the metal parts of the container. He next used a solution of methylene blue, which worked very satisfactorily. This produced a blue light, with little heat, the color also aiding the destruction of the bacteria. In these experiments sunlight was mostly used and was found to be most powerful on account of containing the most chemical rays. But the uncertainty of the sun and change of strength at different seasons of the year made sunlight very unsatisfactory and the electric arc light was adopted. This also was found to contain many chemical rays, which is not so with incandescent light.

Finsen made a test with a Vogel photometer, in Copenhagen, October 27, 1896, at 11:15 A. M., in the open air, and found the sunlight eight times stronger chemically than an arc light of 25 amperes. June 21st, the sun was only six times stronger. All sunlight experiments were made in clear weather.

In valleys and dense moist air many of the ultra-violet rays are absorbed by passing through the atmosphere. On high mountains, where the air is pure and rare, the sunlight is very rich in violet and ultra-violet rays. Electric light is preferable on account of being of the same strength at all times. Glass and water lenses were used for concentration of the sunlight. Water lenses proved to be the best, as it was difficult to obtain good glass lenses of large size. For sunlight Finsen used as large a lense as was obtainable at that time.

The apparatus for electric light has to be differently constructed, because the light is more divergent than sunlight. It is necessary to have crystal lenses in place of glass and distilled water in place of blue water. By the foregoing experiments we see that it must be the violet and ultraviolet rays that kill the bacteria. All the others are heat rays, except the green, which seems to have no influence of any consequence.

Prof. Bie also found that some of the ultra-violet rays are absorbed by glass lenses, but not by quartz crystal. In using sunlight some of the ultra-violet rays could easily be lost without weakening the strength of the light, the sunlight being six to eight times stronger than electric light, but in using electric light with smaller lenses, we must have all the violet and ultra-violet rays possible in order to get any appreciable effect in a reasonably short time.

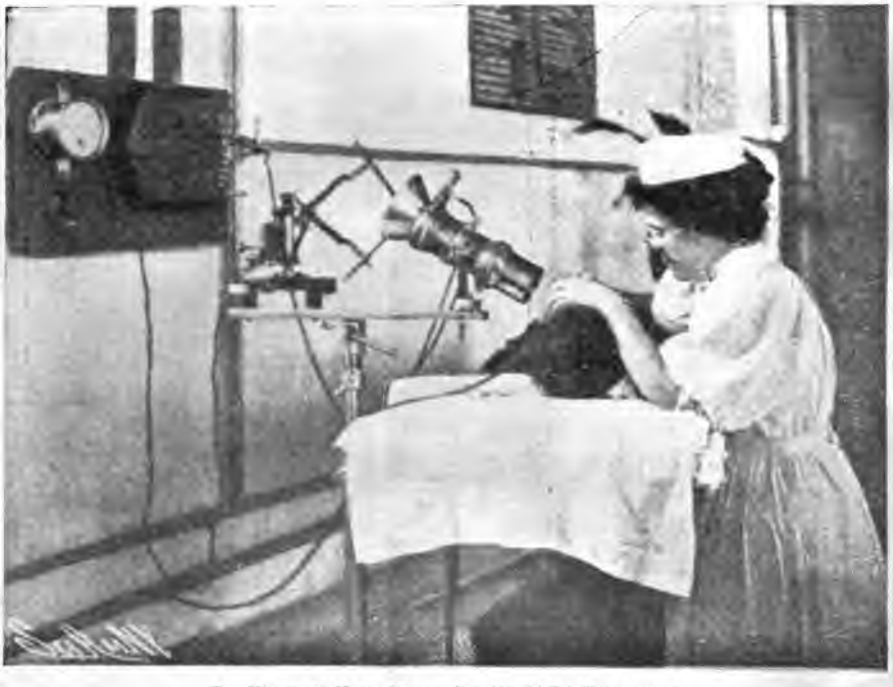
On May 22, 1897, at 10:30 P. M., Finsen made a test with an 80 ampere lamp and an apparatus consisting of two crystal lenses, one 6 cm. the other 5½ c. cm. diameter. They were separated by a distance of 6 cm., the space being filled with distilled water. He exposed to the light passing through this apparatus and a quartz crystal lens, a culture of anthrax bacillus for five minutes. He then substituted a piece of common window glass in place of the quartz crystal and exposed another culture for five minutes. Then he used in place of the window glass a piece of plate glass and exposed a third specimen for five minutes. The next day at 1:30 all three plates showed weakness in growth. The two which were exposed to the light passing through the glass plates were about the same. The one exposed to the light passing through the crystal lens was very much weakened. Twenty-four hours after the exposure, most of the culture exposed to the light passing through the crystal was dead, a few colonies which developed were weak in growth. The two treated through the glass plates were developing evenly and good. The bacilli were all pigmented and a little darker where they were treated with the light.

Dr. Bie used an apparatus of the same kind and a lamp of 35 amp. and killed a culture of the same kind, in 35 minutes. Finsen used the same kind of apparatus with a 7 cm. crystal lens and killed a culture of the same bacillus in two to three seconds with a 35 ampere light. July 13, 1896, Berton made a test in the Academy of Science with the Roentgen ray. He exposed a culture of diphtheria bacillus to the ray for 16, 32 and 64 hours without killing or even weakening the growth of the culture. (Ref. in *La Sem Medicale*, July 22, 1896, p. 263.)

Could crystal lenses of larger size—say 10 to 12 cm. diameter—be easily and cheaply obtained, sunlight could, at times, be used to good advantage, but crystals of that size are rare and very expensive. They cost, in Europe, from $35 to $50 apiece. Crystal lenses, 6 to 8 cm. diam., are plentiful and cheap, $5 to $6 apiece. With electric light the size of the lens makes no difference, but it must be large enough to keep the light far enough away to prevent overheating, which would break or dull the lens in a short time.

Finsen used crystal lenses as early as 1895, but at that time he had an arc light of low power and therefore required very large lenses, which were very hard to obtain and were very expensive. He then used again glass lenses until he constructed the present apparatus.

To remove all heat from the light is impossible, as all rays contain some heat, but the object is to remove as many heat rays as possible and especially those which are of no value in killing bacteria. A patient can conveniently stand about 45° to 55° C. It is therefore necessary to have an apparatus which does not develop more than 55° C. at the focal point and at the same time contain enough chemical rays to destroy bacteria.



Dr. Finsen's New Apparatus for Light-Treatment.

For the heat test Finsen used a 35 ampere light and a thermometer, the ball of which was blackened with soot. The thermometer was at all times placed in the focus of the light. 1. The apparatus was used without water and produced an average temperature of 325° C. 2. The apparatus was filled with water and then had an average temperature of 111° C., the light passed through 13 cm. of water. This was a reduction of over 200° C.

In order to find out if all the red and ultra-red rays had been absorbed, Finsen used a light filter 1 cm. thick

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iodide of sulphur. This solution
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nearly all heat rays, the thermom-
6° C. This proved that the water
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bsorbed. But a large quantity of
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wing tests: First, he used water in
erature 5° C., this gave, a tempera-
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ture of 45° C., this gave a temp-
.nt of 198; water at a temperature
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is is of great importance, because
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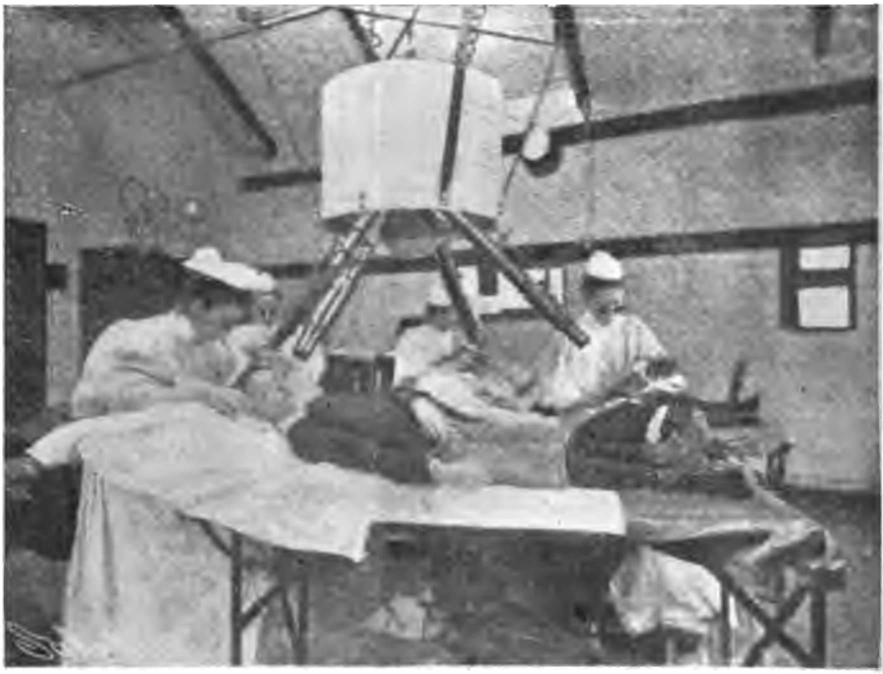
ıtient.

In the first lights which Finsen constructed with glass lenses, a solution of sulphate of copper or methylene blue was used. A filter of sulphate of copper 1 cm. thick would reduce the heat in the focal point from 111° C. to 34. The light passing first through 13 cm. of water. A methylene blue filter, of the same thickness, would only reduce it to 57° C. But since the apparatus is so constructed that quartz crystal lenses can be used, it is no longer necessary to use chemical solutions, as the crystal lenses themselves absorb a large quantity of heat rays. Distilled water is used on account of deposits of lime salts, forming from ordinary water, and because the decomposition of the vegetable matter in the water causes air bubbles to deposit on the lenses. In order to penetrate deeply into the tissues it is necessary to render the part to be treated anemic, and for this purpose Finsen constructed compressors. They are of different shapes to facilitate the treatment of the various parts of the body. By having the compressors hollow they can be cooled with running water. The part that is to be treated can be perfectly cooled so that the patient is not aware that the light is applied.

Since the adoption of the compressors, a more powerful light can be used. Where formerly only 35 to 50 amperes could be used, now a lamp of 60 to 80 amperes can be comfortably applied, not only because the compressor renders the parts anemic, but mostly on account of its being composed of quartz crystal lenses.



The large Finsen Apparatus with 4 tubes is operated with a 60-80 ampere arc light. The construction of the tubes is the same as the small light. The tubes are made longer to allow the patients to be grouped around the light with ease and comfort.

Quartz crystal is a more rapid conductor of heat than glass and therefore cools the passing rays very rapidly and imparts the heat to the running water. The statement that warm or hot water absorbs heat rays, also holds good with the compressors, but since the compressors are applied directly to the skin they would in time become too warm and be uncomfortable for the patient. Finsen used quartz crystal compressors for his sunlight apparatus, before the present electric light was completed.

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